



Plasma Technique for Modification of The Natural Thickener to Improve Textile Printing Performance

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CHEMICAL modification was used in the process of extracting natural thickeners from seeds at an early age as a tool to impart new properties to them and increase their effective use in various medical and food fields and also used in industrial applications such as textile printing. Nowadays, physical techniques can replace some of these chemical modifications as processes Safe and environmentally friendly. Plasma treatment is one of these physical techniques applied to the treatment of thickeners and to improve their rheological properties and use them in textile printing processes. It is a rapidly growing field and in our current time it is preferable to use these physical techniques to replace chemical treatments in medical and industrial applications and as an environmentally friendly process. Plasma treatment does not involve the use of hazardous chemicals harmful to the environment, and therefore there are no effluent problems compared to chemical treatment.

Keywords: Plasma, Textiles Fabrics, Printing Process, Extraction of Natural Thickener.

Introduction

Textile Fibres

Textile fibres, can be identified by their flexibility, fineness, and high length-to-thickness ratio. A monomer is a molecular segment that acts as the main structural component of a textile fibre and is employed repeatedly to generate large chains or molecules. It is significant to classify textile fibres according to their origin since the physical and chemical properties of fibres from different origins differ greatly. As a result, both of the main groups of fabrics are divided into natural and man-made fibres. [1, 2]

Vegetable fibres (cotton, flax, hemp, kenaf, sisal, and other), animal or proteinic fibres (wool, silk), and

non-organic or mineral fibres (asbestos) are the three types of natural fibres.

Man made fibres are those, which are produced in industrial conditions and mainly, consist of organic heterochain and cabochian compounds; only a small part, of natural non-organic compounds.

Classification of Textile Fibres

Fibres can be classified as the following in Figure 1. [3] As a result, we shall investigate one of each of them as the most commonly used fibres in textile manufacturing. In the following summary of cotton, wool, and polyester.

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Cotton Fibres

Cotton is the most essential fibre in the textile business because it is soft and breathable. As a consequence of this, it has become the most popular type of textile found in clothing. [4-8] Cotton fibres came from bolls of the plants had almost entirely of polysaccharide cellulose. The fibre properties are determined by its chemical composition and structure.

Cotton Fibres Composition

Cotton fibre is the purest form of cellulose, though the specific proportion varies with the source of the cotton and the growing conditions. Also, for a given cotton fibre, the composition differs between the fibre surface and the interior of the fibre. An average composition by percentage of (dry) cotton fibre is shown in Figure 2. [9, 10]

Classification of fibres

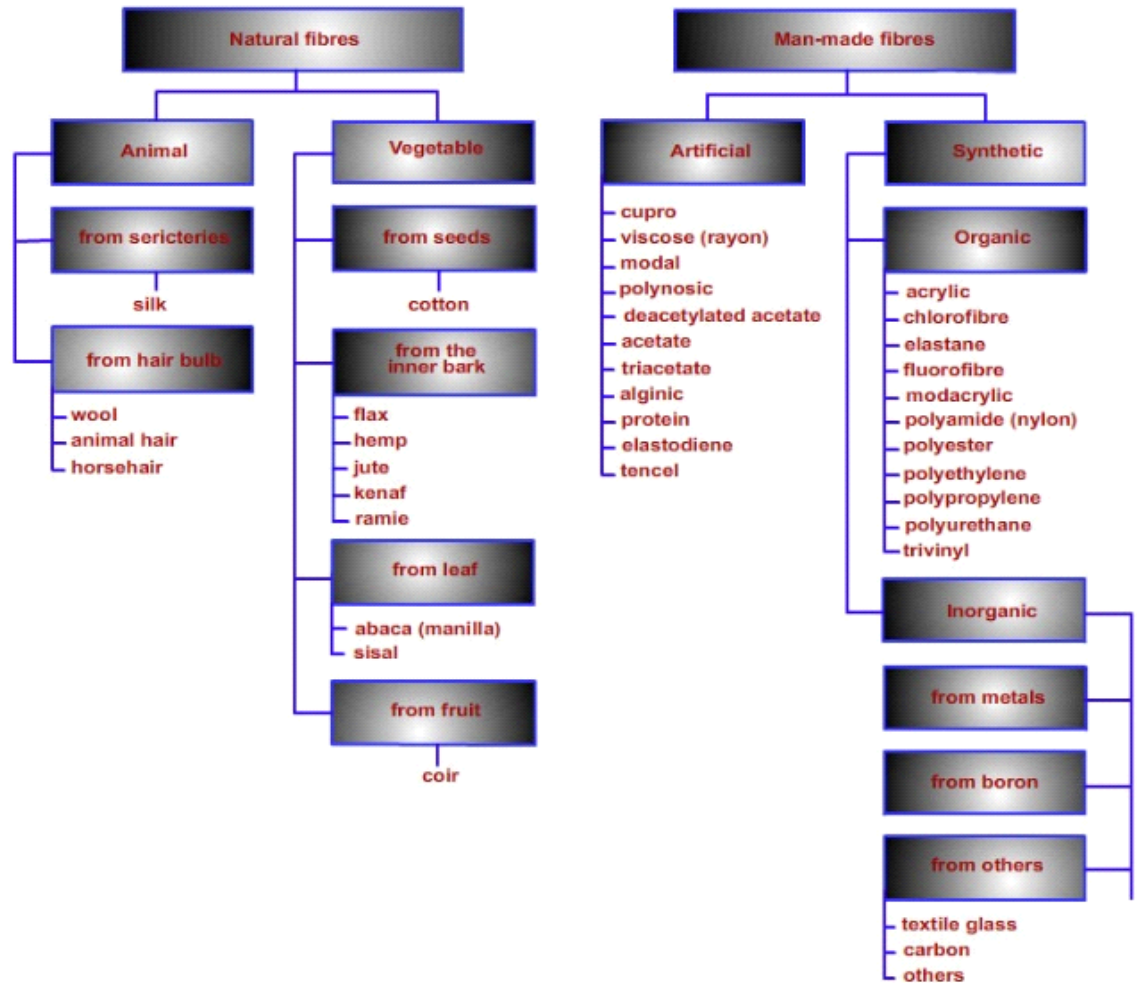


Figure 1: Natural fibres and manufactured fibres [11]

Constituent	Composition of a Fibre			Composition of the cuticle%
	Typical %	Low %	High %	
Cellulose	94.0	88.0	96.0	
Protein (N-6-25)	1.3	1.1	1.9	30.4
Pectic Substances	0.9	0.7	1.2	19.6
Wax	0.6	0.41	1.0	17.4
Mineral Matters	1.2	0.7	1.6	6.5
Maleic, citric and other organic acids	0.8	0.5	1.0	
Total Sugars	0.3			
Cutin				8.7

Figure 2: The general state of knowledge of the chemical composition of a mature cotton fibre

The Figure 2 shows that the percentage of non-cellulosic material by weight of the fibres is very small. These materials are amorphous and are present in the stratum corneum and lumen. The cuticle Figures a protective layer that protects the cotton from environmental influences and water seepage. The waxy material is mainly responsible for the non-absorbent properties of the raw cotton. Pectin also plays a role because 85% of the carboxyl groups in pectin are methylated.

Raw cotton fibres must undergo several chemical processes to obtain properties suitable for use. Washing removes the non-cellulosic substances (wax, pectin, protein, hemicellulose) around the cellulose core of the fibre, making the fibre hydrophilic and suitable for bleaching, dyeing and other processing. Removing pectin makes it easier to remove all other non-cellulosic substances. The biological cleaning process used today is based on the breakdown of pectin by enzymes

Chemical Structure of Cotton

Cellulose is one of the main components of cotton fibres. The chemical composition of cellulose is simple, consisting of anhydro glucose units linked by β -1,4-glycosidic bonds to Figure linear polymer chains Figure 3. The chain length or degree of polymerization (DP) of a cotton cellulose molecule represents the number of anhydro glucose units linked together to Figure a chain molecule. The DP of cotton can be as high as 14,000, but can easily be reduced to 1000-2000 with various caustic wash treatments. Crystalline regions may have a DP of 200-300. Therefore, the molecular weight (MW) of cotton is typically in the range of 50,000-1,500,000, depending on the source of the cellulose. The individual chains are connected to each other along their length by hydrogen bonds and van der Waals forces. The physical properties of cotton fibre, and the chemical behavior are determined by the arrangement of cellulose molecules. [6, 12]

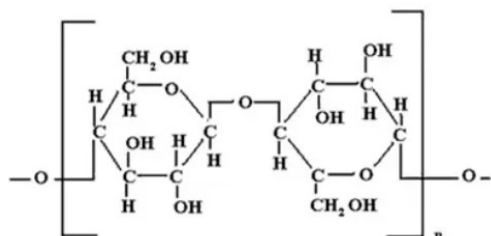


Figure 3: Chemical Structure of cellulose

Physical and Mechanical Properties of Cotton

Microscopic investigation

Cotton, the seed hair of plants of the genus *Gossypium*, is the purest Figure of cellulose readily available in nature. It has many desirable fibre properties making it an important fibre for textile

applications. Cotton is the most important of the raw materials for the textile industry. The structure of a cotton fibre composed of microfibrils, which build up the primary cell wall and the three layers of the secondary cell wall according to a typical orientation. The fineness of cotton fibres varies between 1 and 4 dtex, and the length varies between 10- and 60-mm. Cotton fibre lengths are mostly between 25 and 30 mm. The density is 1.50 to 1.54 g/cm³ (see **Error! Reference source not found.**) [10, 13, 14]

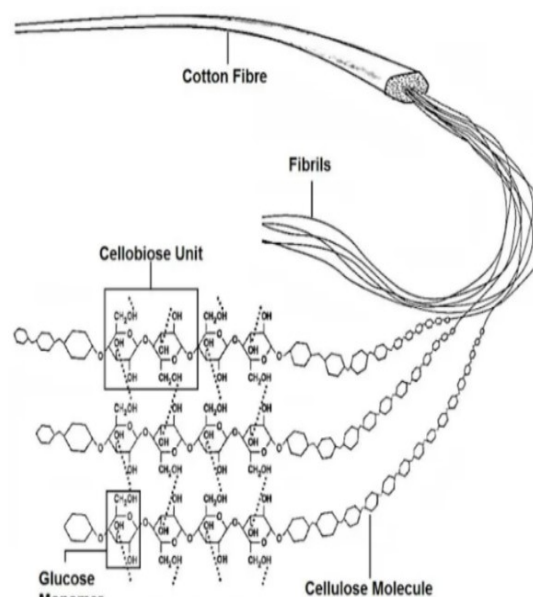


Figure 4: Chemical Structure of cotton fibre

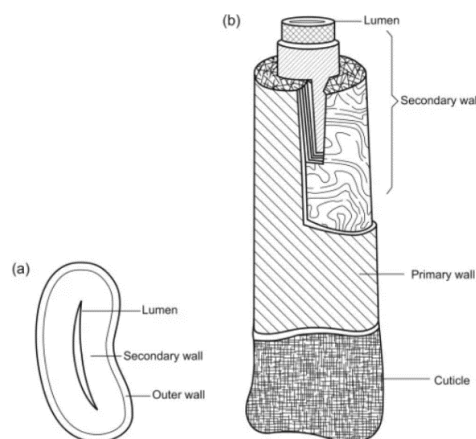


Figure 1: Physical structure of cotton fibre
(a) Cross-section and (b) vertical section

Tenacity

The strength of cotton is enhanced by its long polymers, an endless array of standard hydrogen bonds between adjacent polymers. It is one of the few fibres to gain strength when wet, which occurs due to a more developed plan in undefined areas of the fibre. The wet strength of cotton is 20% higher than the dry strength. [15]

Elastic-plastic nature

Due to its glassy polymer structure, cotton fibres are inherently inelastic, hence these fibres are prone to blemishes and wrinkles. Polymer particles can slide past each other, especially under considerable pressure, because their long length and infinite hydrogen bonds between. As a result, the cotton strands are creased considerably under the action of the energy. Cotton has a flexible recovery rate of 74% at 2% boost and 45% at 5% scaling. [6, 12, 14, 16-22]

Hygroscopic nature

Cotton particles are highly moisturizing due to their abundant polar OH bundles that attract water atoms. However, OH atoms can enter cotton particles through star-like trajectories because the intermolecular space in the translucent region is small. Cotton threads usually feel fresh on the touch because they absorb moisture from the skin of the fingers. The fibre's hygroscopic concept expects cotton materials to promote tribo-based electricity. The ends of the water atoms are attracted to the hydroxyl clusters of the polymer, so the electrostatic charge dissipates. Standard moisture recovery is 8.5%. [23]

Absorbency

Cotton has the property to absorb liquid in large quantities. It has a capacity to absorb liquid up to 27 times its weight. This makes cotton comfortable to wear as it absorbs sweat well. For this reason, it can be used to manufacture towels and washcloths.

Colour

The colour of cotton fibre could be white, creamy white, bluish white, yellowish white or grey. [4]

Storing effect

Cotton shows a small loss of strength when stored carefully. After 50 years of storage cotton may differ only slightly from the new fibres. [6, 12]

Thermal Properties

Cotton has an excellent resistance to degradation by heat. It begins to turn yellow after several hours at 120°C and decomposes at 150°C. As a result of oxidation, cotton is severely damaged after few minutes at 240°C. Cotton burns in air. [11, 24]

Chemical Properties of Cotton

Effect of acid

Cotton fibres are weakened and destroyed by acid as acidic conditions hydrolyse the cotton polymer at the glucoside oxygen atom of the cellulose unit. Cotton polymers are more rapidly hydrolyzed by mineral acid than organic acid. [4, 13]

Effect of alkali

Cotton fibres are not attacked by alkali because there is no attraction between polymer and alkali. Mercerizing without tension or loose can swell cotton fibres. The main reason for swelling is that alkalis and bacteria enter the amorphous regions of the fibre-polymer system, pushing the polymer far away, causing swelling. As a result, poorly oriented polymers can align themselves more orderly, thereby increasing fibre strength. The increase in toughness after mercerization under stress can be explained by the fact that the alkaline liquid helps to break hydrogen bonds. It also makes the fibres smoother and more regular, allowing it to reflect light more evenly and giving it a soft sheen. [11, 24]

Effect of bleach

Sodium Hypochlorite and sodium perborate are the most common bleaching agents used on cotton textile. Sodium perborate, a white powder, bleaches cotton fibres at room temperature. Bleaching with sodium perborate is more effective at temperature more than 50°C. The bleach is effectively in an alkaline medium.

Oxidizing bleaches liberate oxygen and hence the interaction between the oxygen liberated by bleach and the molecules of fibre surface causes the discoloration of cotton. It is found that oxygen liberates water-soluble molecules with the fibre which are rinsed off by washing. Carefully bleaching the fabric can protect the fabric from chemical attacks of the bleach. [6, 12, 25]

Miscellaneous Properties of Cotton

Colouration properties

Cotton fibre can be dyed by azoic dye, direct dye, reactive dye, Sulphur dye and vat dye. It is one of the easiest fibres to dye and print. This is due to the polarity of the polymer molecules of the cotton fibre. Hence this attracts any polar dye molecules in the polymer system. [26, 27]

Wrinkling

Cotton fabric is easy to wrinkle to improve its appearance, it is ironed regularly. Hence, it is also modified and finished well to resist wrinkles.

Shrinkage

Cotton fabric has the tendency to shrink after the first wash. By a small amount, avoid this. Some cotton fabrics come to the shopkeeper pre-shrunk for sale. Thus, they do not have to get worried about getting small after the first wash.

Breathability

Cotton fabric is comfortable soft hand due to allowing air to pass through smoothly. It is a good

absorbing of sweat. Hence it is a great choice in hot and humid seasons.

Effect of sun light

There is a gradual loss of strength when cotton is exposed to sun light and the fibre turn yellow. The degradation of cotton by oxidation is done when heat is promoted and encouraged. by sun light Much of the damage is caused by UV-light and by the shorten weaves of visible light. [10]

Wool Fibre

Wool is a natural fibre. Wool is the most commonly used animal fibre. The fibre is obtained from the soft, hairy covering of sheep and sometimes goats.

Wool Fibre Composition

Wool is considered to be a protein called (main fibre component "Keratin" 33 %) Chemically this protein consists of 5 elements.

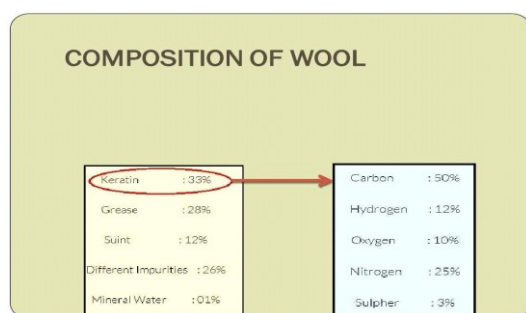


Figure 6: Wool fibres composition ⁽⁵⁾

Chemical structure of Wool

Wool is different from other fibres because of its chemical structure. This chemical structure influences its texture, elasticity, staple and crimp formation. Wool is a protein fibre, composed of more than 20 amino acids

Glycine, alanine, valine, tyrosine, lysine, glutamic acid and cysteine... etc.

These amino acids are natural high molecular weight polymers. Proteins are formed by the condensation reaction of 1-alpha-amino acids through their

carboxyl and amino groups. Dipeptide formed by condensation of two amino acid molecule. The repeating unit (-NHCHRCO-) is called a peptide group Figure 8. [20, 21]

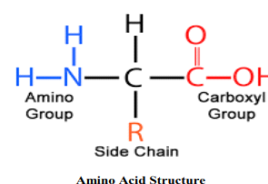


Figure 7: Amino acid structure

Dipeptide formed by condensation of two amino acid molecule. The repeating unit (-NHCHRCO-) is called a peptide group. [18, 21]

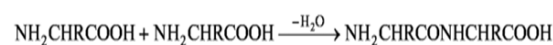


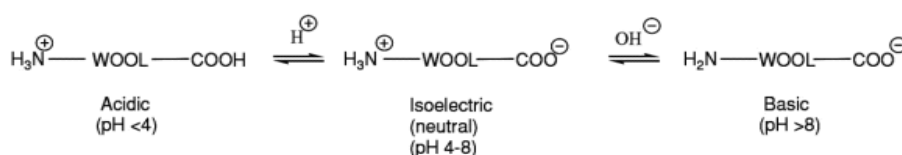
Figure 8: Condensation of two amino acid molecules

The side chains of wool contain approximately equal numbers of basic groups and acidic carboxyl groups. These groups are responsible for both types. The properties of the fibres and their ability to bind large amounts of acid or basic show that when neutral, both types of groups are fully ionized and the net charge carried by the fibre is zero. [26, 28]

Physical Properties of Wool

Wool microscopy

Wool fibres are composed of three morphological components (Figure 9-13) Cuticle, the outer surface, is composed of a crusty substance composed of clear cells in the Figure of scales or scales that Figure on top mutual. This layer imparts firmness and resistance to the hair pressure. [29, 30] The cortex It is this layer that forms and gives the body of the filament Its mechanical properties such as durability and flexibility. [31, 32] The medulla consists of a layer of cells in the middle of the filaments It usually contains coloured materials that give wool its natural colour. The size of this layer varies from filament to filament in wool fashion. [23, 33]



Amphoteric nature of wool

Figure 9: Amphoteric nature of wool

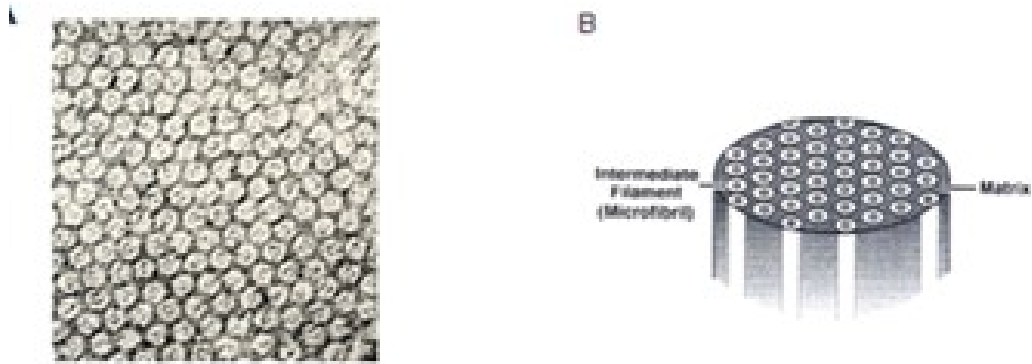


Figure 11: TEM image for wool filaments

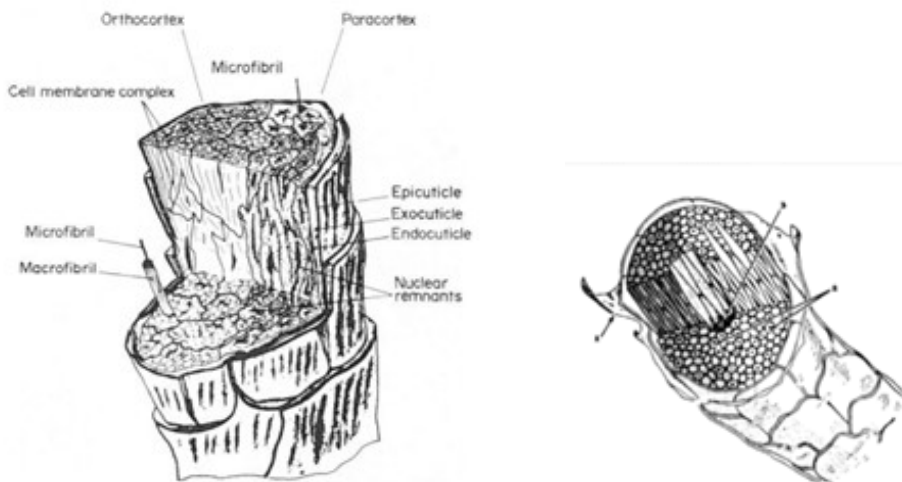


Figure 12: Microscopic view of broken section of wool fibre

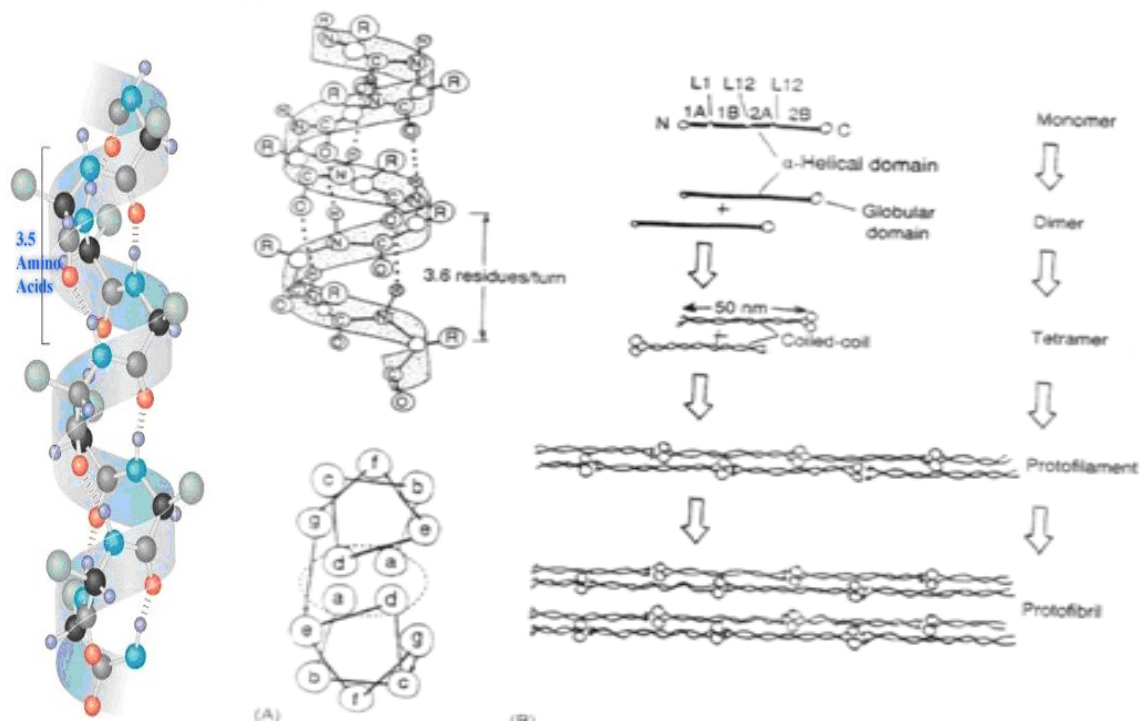


Figure 13: Intermediate filaments in wool
 (a) alpha-helix and coiled coil dimer and (b) structure of intermediate filaments in wool

Colour

The colour of the wool varies between white, black, brown and sometimes grey, White makes up the vast majority of wool to varying degrees, and is Preferable than other colours as it can be light and bright colour. [33, 34]

Durability

The durability of wool depends on the durability of the fibre, which depends on its type of wool. Factors that affect wool durability include inner fibre and scale covering, animal health and his level of care. External factors such as heat and light intensity also affect wool durability. These factors make wool fibres less elastic compared to pure cotton, Wool is more durable than cotton. [27, 35]

Elongation

The elongation at break of wool fibres at standard conditions is 25-35%, and 25-50% when wet⁽²⁸⁾ [33-35]

Thermal effects

Wool softens and loses softness when heated in boiling water Prolonged exposure at 130°C; it decomposes and turns yellow at 300°C.

Chemical Properties of Wool

Wool interacts with many chemicals, as wool contains reactive groups:

Effects of acid

Concentrated sulfuric acid dissolves wool fibres completely, but wool is resistant to diluted and concentrated other mineral acids even at high concentrations and temperature. Keratin wool is sensitive to chemicals. [18, 32]

Effect of alkali

The chemical properties of wool keratin are sensitive to alkaline substances such as wool is soluble in caustic soda. [18, 32]

Effect of bleach

Wool fibres are sensitive to chemicals. H₂O₂ is mainly used in wool. Bleaching is carried out by controlling the bleaching conditions so that the fibres are not damaged. Wool and is damaged by sodium hypochlorite solution, so hypochlorite-based bleach should not be used on wool. [36, 37]

Characteristics of Wool Fibres and Products

- Antistatic: Because wool absorbs water vapor, it does not generate static electricity, so it is less likely to stick to the body uncomfortably than other fabrics.
- Anti-wrinkle: On a microscopic level, each wool fibre acts like a coil spring, returning to its

natural shape when bent. This makes wool garments naturally wrinkle-resistant.

- Biodegradable: When wool is discarded, it naturally degrades in the soil for months to years, releasing valuable nutrients back into the soil.
- Breathable: Wool fibres can absorb large amounts of water vapor, which is then drawn away and evaporated into the air. Wool clothing is very breathable and not easy to sweat.
- Fire resistant: Wool is flaming retardant, won't melt or stick to skin, and even self-extinguishing if produced at source.
- Odourless: Unlike synthetic fibres, wool absorbs moisture, which means your body sweats less. They even absorb and bind sweat odours, which are then released during the wash.
- Renewable: Sheep produce a new wool every year, making wool a fully renewable source of it.
- Stain resistant: Wool fibres have a natural protective layer that prevents stains from being absorbed. Since wool does not generate static electricity, it attracts less dust and fluff.
- Soft: Wool fibres are so fine that they flex and feel soft and gentle against your skin.
- Sun protection: Wool protects the skin from UV rays better than most synthetic fibres and cotton. So, it is safer for the whole family to wear wool on sunny days.
- Warm and cool: Unlike synthetic fibres, wool is a reactive fibre that responds to changes in body temperature.

Polyester Fibre

Polyester fibres are "man-made fibres of which the fibre-forming substance is a long-chain synthetic polymer consisting of at least 85% by weight of glycols (HOROH) and esters of terephthalic acid (p-HOOC-C₆H₄COOH)". The most common Polyester fibres are made from the linear polymer polyethylene terephthalate, often referred to simply as PET Figure 14. High strength, high modulus, low shrinkage, heat set stability, light fastness and chemical resistance make up the enormous versatility of PET. [6, 38-43]



Figure 14: Polyester fibres

The process flow diagrams for different synthetic fibres vary, but the basic process is the same. Here is the flow chart of synthetic fibre production, Figure 15. It is the basic sequence in the production of man-made fibres. [44]

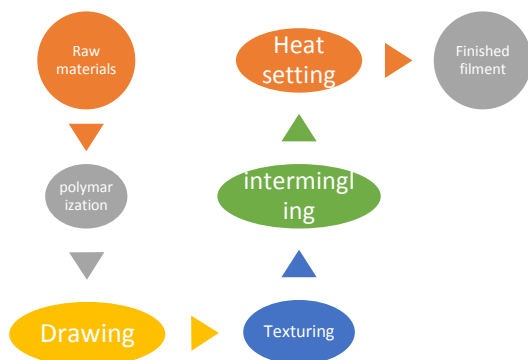


Figure 15: Process Flow Chart of Synthetic Fibre Production

Manufacturing of Polyester Fibre

Polyethylene terephthalate (PET) is a polycondensation made industrially from terephthalic acid or dimethyl terephthalate and ethylene glycol. [26, 45, 46]

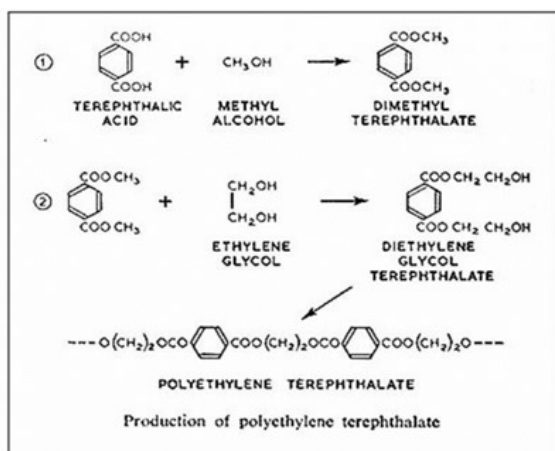


Figure 16: Manufacturing of polyester fibre

Poly terephthalic acid (PTA) is produced directly from para-xylene by bromide-controlled oxidation. Dimethyl terephthalate (DMT), is produced by esterification of terephthalic acid.

Synthesis of Polymer

Linear polyesters: As, (PET) is polymerized in one of two ways; transesterification of diethyl terephthalate and ethylene glycol monomers. ^(33,34) and direct etherification of terephthalic acid and ethylene glycol. Both transesterification and direct

esterification processes are combined with a polycondensation step, either batch or continuous. Batch systems require two reaction vessels; one for esterification or transesterification and the other for polymerization. A continuous system requires at least three vessels; one for esterification or, one for reducing excess ethylene glycol, and another for polymerization. [46]

Another method of producing PET is solid state polycondensation. During this process, melt polycondensation continues until the prepolymer has an intrinsic viscosity of 1.0-1.4 poise, at which point the polymer is cast as a solid. pre-crystallize by heating (above 200°C) until the desired molecular weight is achieved. Subsequently, the granular polymer is melted for spinning. The process is not suitable for textile PET fibres, but is used for some industrial fibres.

Branched and crosslinked polyesters is created when glycerol reacts with a diacid or its anhydride, each glycerol creates a branch point. Such molecules can grow to very high molecular weights. Polymers crosslink when internal coupling (reaction of hydroxyl groups with branched acid functional groups of the same or different molecules) occurs. Rigidly crosslinked polymers are completely insensitive to solvents. [37]

Production of filament

- After the polyester comes out of the polymerization, allow the molten ribbon to cool until it becomes brittle. Cut the material into small pieces and dry completely to avoid irregular consistency.
- The polymer chips melt at 500-518°F (260-270°C) to Figure a syrupy solution. The solution is put into a metal container called a spinneret and forced through its small holes, which are usually circular but can also be pentagonal or any other shape to Figure special fibres. The number of holes on the spinneret determines the size of the yarn as the exiting fibres are gathered into a single strand.
- Other chemicals can be added to the solution during the spinning stage to make the resulting material flame retardant, antistatic or easy to dye.

Physical Properties of Polyester

Polyester microscopy: It is given in Figure 17.

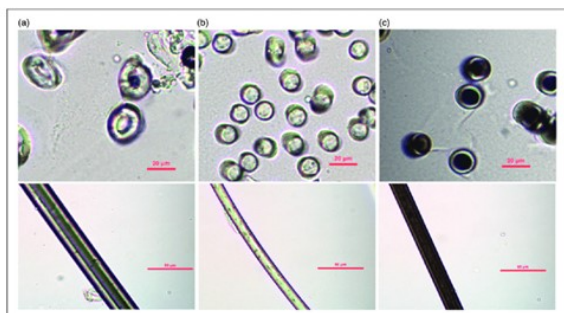


Figure 17: cross-section and longitudinal microscopic of polyester fibre

(a) hollow fibre, (b) PET and bicomponent PET.

Optical properties

PET has optical attributes of numerous thermoplastics, giving splendid, sparkly impacts attractive for some end utilizes, for example, silk-like attire. Polyester microfibre with a direct thickness of under 1.0 denier per fibre (dpf), accomplishes the vibe and gloss of regular silk.

Thermal properties

The thermal properties of PET strands rely upon the technique for make. The glass progress range is as a rule in the scope of 75°; crystallization and dissolving ranges are around 130° and 260°C, respectively.

The General properties of polyester fibres are:

- Strong
- Resistant to stretching and shrinking
- Quick dry
- Brittle and elastic
- Anti-wrinkle
- Mildew proof
- Wear-resistant
- Preserves heat set folds and creases
- Easy to wash

Chemical properties of Polyester Fibre

Effect of alkali

Polyester fibre has good weak alkali resistance at high temperature. It is only moderately resistant to strong bases at room temperature and degrades at high temperatures.

Effect of acid

Weak acids, even at boiling point, will not affect polyester fibres unless the fibres are exposed for a few days. Polyester fibres are very resistant to strong acids at room temperature. Prolonged exposure to boiling hydrochloric acid can damage

fibres, while 96% sulfuric acid can cause fibre degradation.

Effect of solvent

Polyester fibres are generally resistant to organic solvents. Chemicals used for cleaning and decontamination will not harm it, but hot m-cresol will damage fibres, and some mixtures of phenol and chloroform will dissolve polyester fibres. Oxidizers and bleaches will not attack polyester fibres.

Various properties

Soaps, synthetic detergents, and other washing aids won't hurt it. One of the most serious drawbacks of polyester is its lipophilicity. It absorbs oily substances easily and holds the oil stubbornly.

Colouring Properties

Due to its unbending construction, advanced crystallinity and absence of receptive dye sites, PET retains next to no colour in regular colour frameworks. Polyester filaments are hence coloured only with scatter colours. [23, 47, 48] A lot of examination work has been finished to work on the dyeability of PET filaments. Polymerizing a third monomer, for example, dimethyl ester, has effectively delivered a cationic dyeable polyester fibre into the full scale sub-atomic chain. This third monomer has presented practical gatherings as the locales to which the cationic colours can be appended.

Another colouring interaction for polyester fibre at low temperature (40°C and beneath) has been accounted for. This technique utilizes a scatter colour in a microemulsion of a little extent of alkyl halogen and phosphor glyceride. The fundamental benefit of this strategy is low temperature handling, yet there stays the ecological issue that is delivered by utilizing poisonous transporters.

One more methodology has been presented. The material business involves a lot of water in colouring processes emanating natural mixtures into the climate. Because of this issue a withering cycle for polyester fibre was created, in which supercritical CO₂ is utilized as an exchange medium. This gives a choice keeping away from water release. It is low in cost, non-poisonous, non-combustible and recyclable. At the point when coloured in a fluid medium, decrease clearing is to be done to settle variety power, which creates more wastewater. Decrease clearing isn't done after supercritical colouring

Uses of Polyester Fibres

- Polyester is often used in clothing fabrics. Several types of clothing are woven from polyester yarn or thread. Examples include polyester shirts, polyester jackets, polyester pants and polyester hats.

- Polyester is also used to make many household materials such as bed sheets, curtains, blankets, Carpets and pillowcases.
- Polyester is also used in upholstered furniture.
- This polymer is in the manufacture of mouse pads.
- Polyester is known to play an important role in the manufacture of certain types of automotive tire reinforcements.
- Polyester fabrics are often used for conveyor belts.
- Seat belts used in automobiles to protect occupants are usually made of components such as polyester.
- Polyester is also used to make coated fabrics.

Printing

Direct, discharge, and resist printing techniques are the three fundamental types of colour printing on fabric. [49-54]

Direct Printing

Direct printing is the most typical method for putting on a colour pattern. It can be done on white cloth or over a fabric that has already been dyed; the latter instance is referred to as over printing. The dyes are often dissolved in a small amount of water, to which a thickening agent has been added to give the print paste the requisite viscosity. Without any additional processing, all pastes or printing materials come into contact with the cloth surface. [54]

Discharge printing

Discharge printing relies on first dyeing the fabric and then printing it with chemicals that will remove the colour from the intended places. [55-57]

Resist Printing

The resist printing method involves imprinting the material with a chemical that will resist dyeing afterwards, as the name suggests. Only the areas not covered by the resist paste will be impacted by the dye, creating a pattern on a coloured background. Chemical (those that use glyoxal-bisulfite adducts or stannous chloride) and physical (those that use wax to prevent the fibre from being dyed) are the two categories of resist styles [56-58]

Each of these printing styles is utilized on one or more of the below-listed application approaches.

Screen Printing

Screen prints allow for more applied colour diversity and have a brighter, more defined

appearance. Compared to those generated by roller printing, hand-made screen prints are also an option.

Semi-automatic and manual screen printing

A flexible, synthetic rubber squeegee is used to push a viscous print paste through the screen's open spaces in order to print. At a steady angle and pressure, the rubber blade is pulled steadily over the screen^(46,47) By mounting the screen on a carriage and moving the squeegee mechanically across the screen, the manual process has been partially automated. For small-scale production, semi-automatic flat-screen printing is still very common. In both hand and semi-automatic flat screen printing the colours are printed one after another with time for drying.

Fully automatic flat-screen printing

It is required to develop a way for printing all the colours in order to accelerate flat-screen printing.

Rotary Screen Printing

The benefits of flat and roller screen printing are combined in rotary screen printing. A cylindrical screen that is in contact with the fabric is continuously rotated. Print paste is fed into the inside of the screen and during printing is forced out through the design areas with the aid of a stationary squeegee. Movement of the screen creates the dynamic pressure required to force the printing paste through the holes; this dynamic pressure is counteracted by the penetration resistance of the fabric and flow resistance of the screen. [59]

Thickeners

The printing industry's usage of artificial thickeners has certain detrimental effects on the environment. [1, 60, 61] Consequently, we emphasize the usage of numerous environmentally friendly materials was emphasized. [62-66] Natural gums serve as thickeners to lessen their influence on the environment. The thickeners' assistance confines the dye to the planned region. Successful printing requires the perfect colour, clear marking, flatness, good hand, and effective use of dyes. [48]

Textile printing is quickly gaining popularity as a method for all types of fibres, fabrics, and apparel. Thickeners are used to turn the colourant into a paste. Let the design handle. accurate colour, precise and flat marks, good grip, and great efficiency. For printing to be successful, dyes are needed. Thickeners are quite viscous and has a high molecular weight.

The primary function of printing pastes is to bind, transfer, and trap colours on appropriate materials. synthetic and natural thickeners were utilized. The necessary viscosity thickeners provided to prevent premature contact between printing components. Printing paste allows the printing components to reach tissue surfaces. Consistency of printing paste is influenced by thickeners' attraction: print consistency Slurry's temperature, elongation,

and storage The characteristics of the created dry film, colour yield, ease of preparation, and elimination of Galactomannan gum attracts considerable attention as well as industrial interests, especially in environmental protection textile printing. Galactomannans are present in polysaccharides especially in the endosperm of some beans Consists of seeds attached to a mannan backbone. The mannan backbone is interconnected by B-(1-4) glycosidic bonds and has galactose side chain residues terminated by ∞ -(1-6). [1, 2] One of the sources of galactomannan is fenugreek seeds.

The galactose: (mannose ratio is 1:1). It has a wide range of applications as thickeners, rheology modifiers and emulsion stabilizers in food, textile, personal care, petroleum processing, papermaking, coatings and other industries. [50] In organic chemistry, carbs are likewise called saccharides (from the Greek word /sákkharon, and that signifies "sugar"). As per the level of polymerization, the saccharides can be arranged into four unique synthetic gatherings: mono, di-, oligo-and polysaccharides Figure 18. [51]

Class	Degree of polymerization	Components
Monosaccharides	1	Glucose, galactose, mannose, fructose, etc.
Disaccharides	2	Sucrose, lactose, maltose, trehalose, etc.
Oligosaccharides	3-9	Maltodextrins, raffinose, etc.
Polysaccharides	>9	Amylose, cellulose, galactomannans, etc.

Figure 18: chemical structure of glucose, fructose, galactose and mannose [6]

Monosaccharides

The least atomic weight carbohydrates are monosaccharides, which cannot be digested into more subdued starches. Three distinct characteristics can be used to arrange monosaccharides; the location of the carbonyl assemblage. If the carbonyl group is an aldehyde (a carbonyl community twofold clung to oxygen, hydrogen, or a substituent R), the monosaccharide is an aldose (for instance, glucose); if the carbonyl 6 bunch is a ketone (a carbonyl community twofold clung to oxygen and to two substituents), the monosaccharide is a ketose (for instance, fructose). Isomers of glucose, galactose, and mannose have the chemical Formula $C_6H_{12}O_6$. Figure 19.

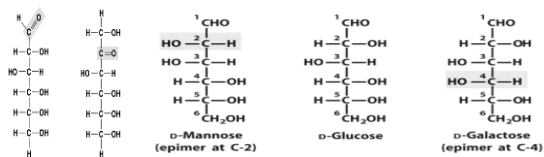


Figure 19: chemical structure of glucose, fructose, galactose and mannose [6]

The most widely distributed natural compound in nature, both as an isolated substance and as a

polymer, is glucose, an aldehydic monosaccharide. D-glucose, also known as dextrose, is a monosaccharide found in a few leafy foods and most natural liquids, including the liver, blood, and spleen, where it serves as a source of energy for both living things and plants. The main product of photosynthesis and the fuel for breathing is glucose. It has a pH of about 7, can dissolve in water (909 g/l at 25°C), and can dissolve 100 g/l of glucose in water at 20°C.

Disaccharides

When two monosaccharides combine, the first with the hemiacetal hydroxyl and the second with any of its hydroxyls, killing a water atom, the result is a disaccharide. A disaccharide is also an acetal when created synthetically; this acetal bond is typically referred to as O-glycosidic. Acetals differ from hemiacetals in that they are not in equilibrium with the reagents; as a result, the acetal bond is stable in neutral or basic conditions as well as with the oxidants commonly employed to recognise the aldehyde or ketone in monosaccharides. Disaccharides can, however, easily be hydrolyzed by acids or chemical. Sucrose is the disaccharide regularly called "sugar" and it is framed by a particle of glucose and a particle of fructose The glycosidic bond includes the glucose aldehyde and the fructose ketone: Figure20.

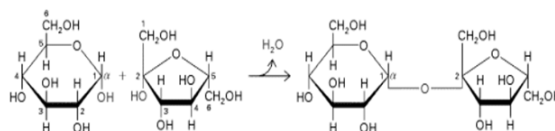


Figure 20: condensation reaction of glucose and fructose [10]

Oligosaccharides

Three to nine monosaccharides are built up to form oligosaccharides. When attached to lipids (glycolipids) or proteins (glycoproteins), they become dynamic organic compounds. Due to a lack of specified proteins, very few oligosaccharides can be digested by organisms during digestion. In this circumstance, the stomach greenery ages them in the digestive system.

Polysaccharides

More than ten monosaccharide linkages and glycosidic bonds surround polysaccharides. They are the most prevalent sugars in nature and may be distinguished in animal and plant polysaccharides like glycogen and starch Figure 21. Homopolysaccharides are polysaccharides that are surrounded by a single type of monosaccharide. In this class of carbohydrates, cellulose and hold the greatest diffusion.

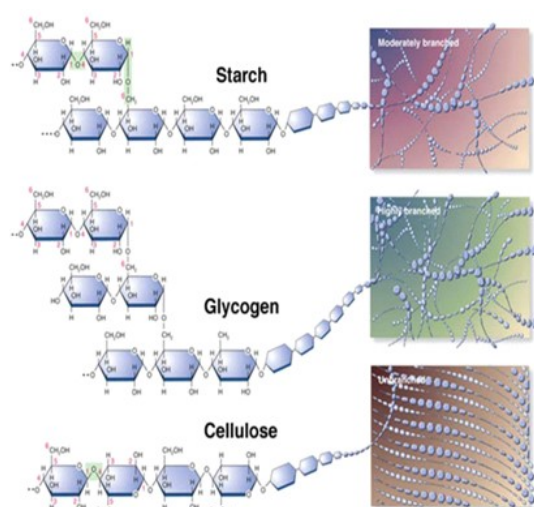


Figure 21: chemical structure of cellulose, glycogen and starch

Industrial polysaccharide

Natural polysaccharides are employed in a variety of commercial sectors, including cosmetics, paints, oil drilling, etc. The sources of polysaccharides are numerous. Alginate, glucan, xanthan, succinyl, gellant, and hyaluronic acid are synthesized by some.

Chitin and sclerodextran are found in fungi and yeast; cellulose, hemicellulose, starch, galactomannans, glucomannan, alginate, and pectin are found in plants, algae, seeds, and roots. Polygalacturonic acid and pectin are found in fruit; starch is found in tubers and grains; Acacia, karaya, and tragacanth exude gums. Polysaccharides can be changed or employed in industry after extraction.

Eight distinct configurations of the hydroxyl group are present in each of the eight configurational isomers of d-hexose Figure 22.

Mannose, galactose, and glucose—are the only ones that are typically synthesized and serve as the building blocks for a few biomolecules and biopolymers. This inclination in normal biosynthesis is because of the setup of the hydroxyl groups.

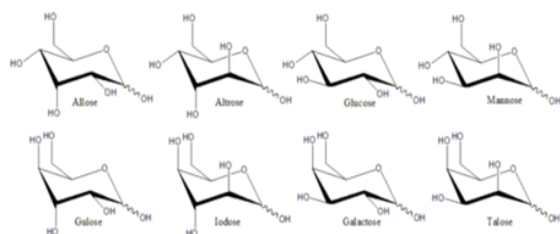


Figure 22: chemical structure of D-hex pyranose

Rheological properties

Polysaccharides are polymers of industrial interest due to their ability to be modified. The rheological properties of the solutions in which they

are dissolved. Rheology is the study train of a flowing liquid or solid structure. It is a disciplined meeting place for numerous. This discipline deals with solid, semi-solid and liquid systems in terms of viscosity, elongation, yield point and elasticity. Rheology studies through reversible, partially reversible or irreversible modifications. Rheological analysis including application the strain γ and when the resulting stress τ is measured, are related to viscoelasticity materials for making samples Figure 23. [1]

A material is characterized as flexible in the event that the energy spent to strain it is completely returned once the pressure is over and the material reestablishes its unique shape. For this situation, the strain is reversible. On the other hand, a material is characterized as gooeey in the event that the energy spent in the strain is totally dispersed and the material doesn't reestablish its underlying shape. For this situation, the strain is irreversible. If a framework acts like an ideal gooeey liquid, the pressure created is in connection with the shear rate $\dot{\gamma}$ applied as per the Newton's Law of Viscosity

Just couple of liquids, similar to water and mineral oils, comply to the Newton's regulation, while for most liquids consistency is definitely not a consistent yet depends, other than temperature and strain, likewise on the shear rate furthermore, time during which it is applied. In these frameworks, the stream beginnings from a specific direction of the particles inside the liquids, with an ensuing increment or reduction of the obstruction inverse to the stream. These liquids are called non-Newtonian: they are the subjects of the rheology studies. As per the kind of reliance on the shear rate, they can be recognized in liquids with plastic, pseudoplastic and dilatant conduct. [67-69]

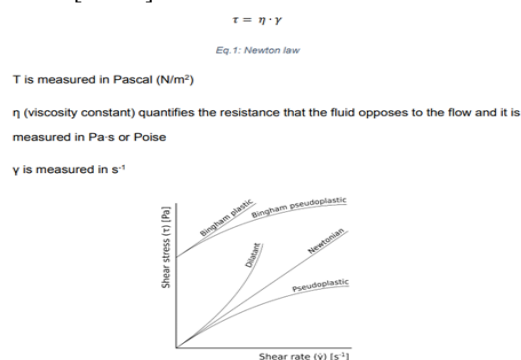


Figure 23: Rheological behaviour of fluids

Dilatant conduct (shear thickening)

Shear thickening liquids act in a contrary manner and their obvious consistency increments at the point when the shear rate increments. A typical model is the suspension of corn starch in water (assuming it is mixed tenderly it is like milk, yet on

the off chance that it is blended quicker it feels extremely gooey). [1]

Polysaccharides, accordingly or changed, are economically utilized as, carboxymethyl cellulose, ethyl cellulose, methylcellulose, galactomannans, xanthan, and so on.

Thickening specialists

Thickening specialists increment the consistency of the arrangement without changing different properties.

- Jellifying specialists: agarose, alginates, and so on. Jellifying specialists are polymers used to create reticulate developments that can entangle water.
- Emulsion stabilizers: carboxymethylcellulose, galactomannans, xanthan's, alginates, and so on. Emulsion stabilizers can forestall the stage division of two immiscible fluids.
- Suspension specialists: carboxymethylcellulose, galactomannans, xanthan's, alginates, agarose, and so on. Suspension specialists are utilized to forestall the precipitation of a solute in a strong fluid scattering.
- Also, all polysaccharides are gotten from sustainable sources and they normally have low costs, great biocompatibility, biodegradability and no harmfulness.

Galactomannans Thickener

Commercial production

All galactomannan is delivered from beans as natural products. Galactomannans are created in the experienced leafy foods. Extraction methodology can be performed subsequent to drying the units.

Composition and Chemical Structure

Galactomannans are an important class of polysaccharides, mainly derived from endosperm dicotyledonous seeds of several plants, especially legumes. Endosperm has versatile. It acts as a reserve source of carbon and energy during germination and has ability to retain moisture and avoid complete seed drying. Galactomannans are high molecular weight polymers. They usually consists of long chains of D-manno pyranosyl units linked by glycosidic $\beta(1-4)$ bonds. The D-galacto pyranosyl unit is linked to a mannose residue via a glycosidic $\alpha(1-6)$ bond. Branching along the main chain leads to different physicochemical properties.

Physical properties

- Found in a highly aggregated state, arranged in particles around the nucleus
- Grains of each starch (rice, potato, wheat, etc.) have characteristic structures that are easily identifiable under the microscope

- Particles need to be broken up by boiling or by grinding and dispersing in hot water to obtain a smooth, sticky paste
- If this paste dries quickly, a starch dispersible in cold water is obtained, but slow drying allows substantial deagglomeration and crystallization to occur

Appropriateness of purpose

- It gives high variety yields because of its conglomeration and exceptionally restricted infiltration into material yarns and subsequently the maintenance of colour on the texture surface.
- In any case, it is typically alluring to arrive at a split the difference between high variety yield, with significant powerlessness to pulverize and unfortunate levelness, from one viewpoint, and low variety yield with great entrance, minimal squashing and great levelness, on the other.
- Conventional strategy for accomplishing such a trade-off was to utilize a combination of starch and gum tragacanth.

Locust bean gum

Locust bean gum, frequently alluded as LBG, is a galactomannan vegetable gum extricated from the seeds of the carob tree. It is also called carubin, gatto, tragon, tragasol. Figure 24.

Structure

It is a straight polymer of (1-4)- connected β -D-mannose units with about each fourth unit conveying a α -D-galactose unit on its carbon number 6.

Business gum contains 88% of D-galactomannan glycan with limited quantity of different sugars and protein.



Carob bean

Figure 24: Carob bean

Guar Gum

Guar gum is synthetically like insect bean gum (It is likewise a galactomannan vegetable gum). The guar plant (*Cyanaposistetragonolobus*) is a yearly leguminous plant. Figure 25.

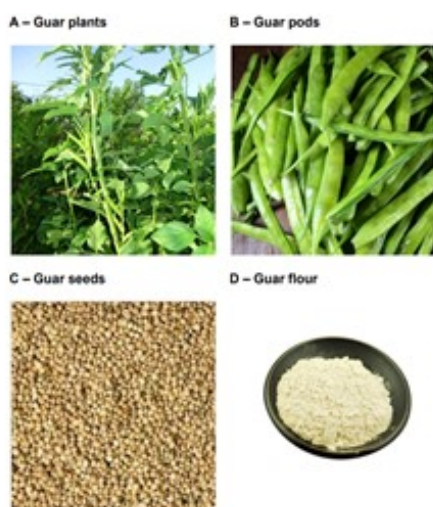


Figure 25: Guar plant, pods, seeds and flour

Structure

It is comprising of D-mannose monomer units connected to one another by β -(1-4) linkage structures spine. Parts of D-galactose joined by α -(1-6) bonds. By and large, The galactose branches happen on each other mannose unit Figure 26.

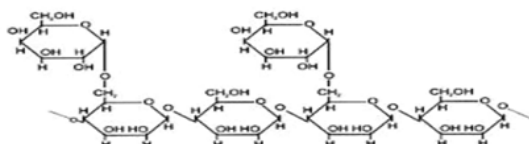


Figure 26: Structure of guar gum

Starch and Cellulose Ether

Adjusted starch is prepared, enzymatically or artificially to get local starch of various change its properties. Ethers are delivered by response with monochloroacetic corrosive and epoxyethane or dimethyl sulfate within the sight of sodium hydroxide. starch structure is shown in Figure 27.

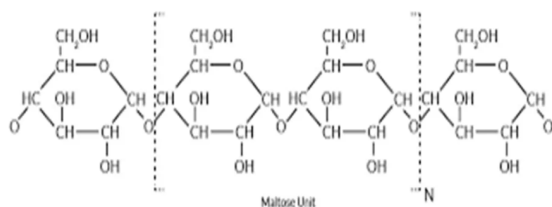


Figure 27: Structure of Starch

Fenugreek

Fenugreek is developed around the world, however the major fenugreek producing nation is India. It fills specially in semiarid areas and it is impervious to high salt fixations. Its sort name, *Trigonella*, alludes to the three-sided state of the seeds, while *faenum graecum* (from Latin "Greek

roughage") alludes to its utilization, in antiquated times, for animals' sustenance Figure 28. [70]



Figure 28: Fenugreek plant, pods, seeds and flour

It is a yearly plant and it can arrive at 60 centimetres of level. The leaves comprise of three little flyers, similar to the ones of clover. The utilization of its seeds and leaves is diffused as elements for dishes from South Asia

Solubility

Galactomannan spine has a comparative compliance to the one of cellulose; the two spines are shaped by β (1-4)- connected pyranoses and both are wealthy in hydroxyl bunches that make them ready to tie and take-up water Figure 29. Cellulose is a homopolymer of glucose, which has all hydroxyl bunches in trans setup.

This impact is forestalled in galactomannans thanks to the cis setup of the hydroxyl gatherings of the mannose units and furthermore to the incessant galactose branches present on the spine.

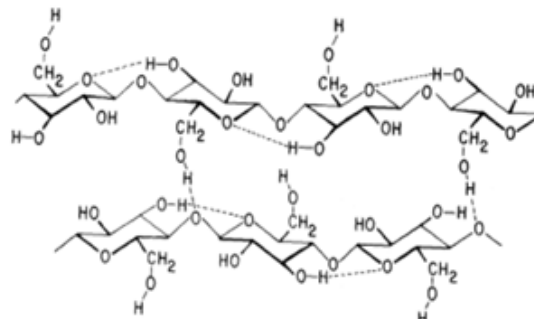


Figure 29: interaction hydrogen bonding.

Moreover, their non-direct chain conformity sterically upsets the affiliation and crystallization of

the chains and it is inclined to shape more vulnerable interchain hydrogen bonds, which can be handily broken and thusly cause a decent solvency. Therefore, galactomannans solvency in water is firmly corresponded to the level of replacement, for example to the mannose-to-galactose proportion: looking at galactomannans from changed sources, obviously the more the polymer is subbed, the higher is its dissolvability. Fenugreek gum, having a mannose-to-galactose proportion of 1:1, has the best dissolvability.

Viscosity

A few galactomannans and their subsidiaries can produce unquestionably gooey arrangements at low fixations. These arrangements are steady over a wide pH range (1-10.5) because of the nonpartisan nature of galactomannans. Corruption happens just at high temperature and in states of extremely high or low pH).

As recently examined, galactomannan arrangements act like non-Newtonian liquids, showing a consistency increment with the abatement of the shear rate. This property is emphatically impacted by the mannose-to-galactose proportion of the galactomannan.

Plasma Treatment

Plasma is the fourth state of matter. It is essentially a very hot ionized gas. It is the cause of the sun and most of the sun universe. Plasma is so hot (millions of Kelvins) that it cannot be physically controlled. [71]

Physical Processes in Plasma

Gases are thought to be good electrical insulators, so when a potential difference is applied between two electrodes in any gas, no current can flow. But it is now known that if a sufficient electric field is established in a gas, and an initial source of ionization is present in the gas, the gas becomes as a conducting state, and a transition from an insulating state to a near-perfectly conducting state can occur. This transition is called electrical gas breakdown. [72] This transition depends on the ionization process taking place in the gas, which occurs at or near the electrode surface. These processes can be divided into two main processes, the ionization process and the deionization process.

The ionization process is divided into two main processes.

- Primary ionization process which is electron-atom collision e.g.

$$e + X \rightarrow X^+ + 2e$$
- Secondary ionization processes that take place in the bulk of the gas e.g. positive ion-atom collision, photo ionization, thermal ionization, excited atom-atom collision, chemical and

nuclear reactions, etc. The secondary ionization processes that take place at the cathode e.g. thermo-ionic emission, photo emission, positive ions bombardment, excited atom impact, field emission, chemical and nuclear reactions, etc. De-ionization processes in the gas include thermal diffusion, recombination, am-bipolar diffusion, etc.

Types of Plasma

Plasma can be divided into various types according to various parameters using the following Figure 30. [73] Plasma classification - according to gas pressure - at high or low pressure has gained great importance in the field of textile processing.

Operating Pressure

Plasma generation can be performed at a variety of pressures, including low (vacuum) and high (atmospheric) pressures. The working pressure of the gas is a critical factor when choosing a plasma source, as it limits the choice of reactor technology and the type of source used for processing applications. In terms of pressure, the most critical choices are to operate the process under vacuum (low) or 1 atmosphere (high).

Low Pressure Plasma

Low-pressure plasmas vacuum have been widely used in materials processing and play a key role in the fabrication of semiconductor devices They produce highly concentrated reactive species ions that can etch and deposit thin films at speeds up to 10 $\mu\text{m}/\text{min}$. Low pressure plasma is a proven surface modification method. Vacuum devices provide a microscopically consistent, chemically mild and mechanically non-destructive method for removing sorbents such as dust, grease and fatty acids or bacteria [74-81] Ions generated in the plasma can be accelerated towards the substrate to enable directional etching of sub-micron features. Operating plasmas under reduced pressure has several disadvantages. Vacuum systems are expensive and require maintenance. Material must be moved in and out of the vacuum using load locks and robotic assemblies. The size of the object to be processed is also limited by the size of the vacuum chamber. [77-82]

DC glow discharge

Glow discharges are the oldest type of plasma. It is produced under reduced pressure and ensures the highest possible uniformity and flexibility of any plasma treatment. [82-84] It is defined as a partially ionized gas containing equal volumetric concentrations of positively and negatively charged species, with varying concentrations of ground state and excited species. This partially ionized gas can be produced by exposing the gas to very high

temperatures or strong electric fields, or by exciting it by radioactive sources or strong light emission ⁽⁶⁹⁾. [78] The electric field is induced by direct current. As shown in Figure 31 a direct current (DC) discharge consists of a self-consistent combination of the cathode surface, cathode dark region, negative glow

region, Faraday dark region, and positive column. Most of the applied voltage appears in the space between the cathode and the negative glow. [78]

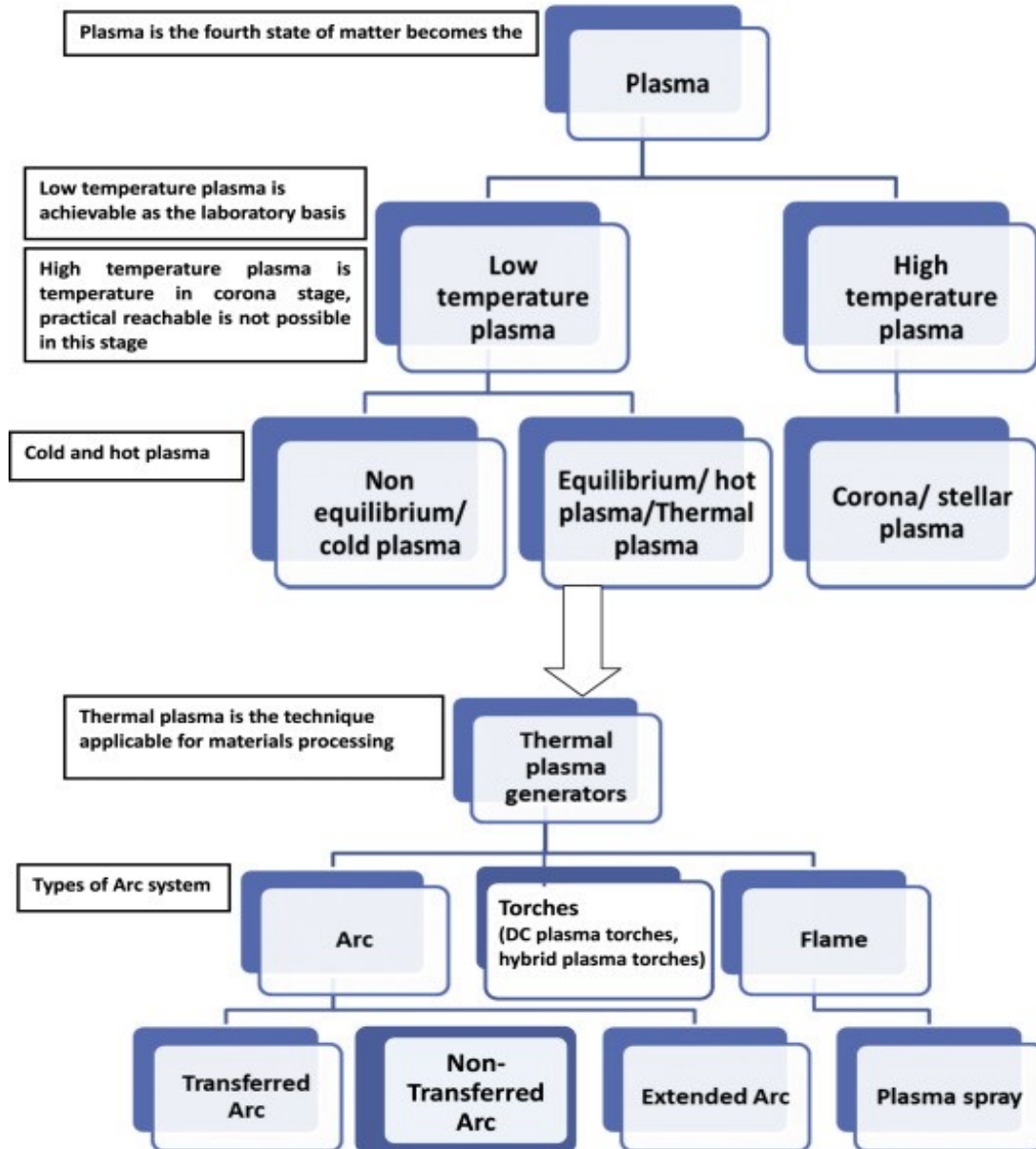


Figure 30: plasma classification.

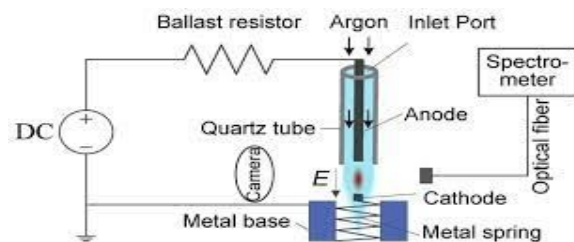


Figure 31: direct current (DC) discharge consists of a self-consistent combination of the cathode surface

High Pressure Plasma (Atmospheric Pressure)

Although most previous research has focused on vacuum systems, their high cost and production limitations have led to the development of higher pressure (atmospheric) devices. To provide a more economical, continuous, or high-speed process, a

working pressure of 1 atmosphere or close to 1 atmosphere is required. Atmospheric pressure plasma overcomes the disadvantages of vacuum operation and provides industrial continuous, large-scale, in-line, open-perimeter processing rather than closed-perimeter vacuum systems. [75, 76, 78]

Atmospheric pressure plasmas are used in various material processes. Conventional sources include transferred arcs, plasma torches, corona discharges, dielectric barrier discharges and plasma jets. In arcs and flares, electron and neutral temperatures exceed 3000°C. [82] In the case of corona and dielectric barrier discharges, non-equilibrium plasmas with gas temperatures between 50-400°C occur.

Plasma torch

The energized electrodes consist of 1 mm thick metal needles. The needle is inserted into a grounded metal cylinder. In addition, a quartz tube was placed between the cathode and anode, making the device similar to a dielectric barrier discharge Figure 32. [82, 85-88]

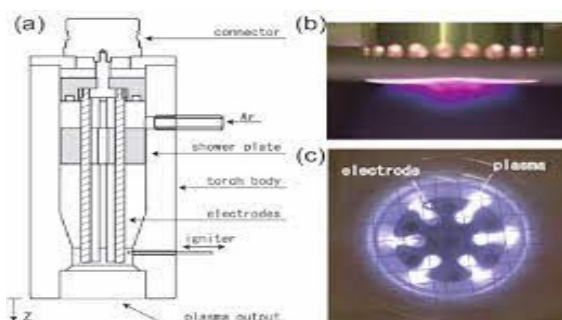


Figure 32: Schematic of a cold plasma torch

Corona discharge

Corona discharges appear as localized luminous glows in the space around point vertices in a highly inhomogeneous electric field. Depending on the field and potential distribution, the corona can be viewed as a thousand discharge or a negative glow discharge. Figure 33 shows a schematic diagram of a point-to-surface corona. The device consists of a metal tip. The radius is about 3 μm , and the distance between the planar electrode and the tip is 4-16 mm. The plasma is typically present in a region of gas extending about 0.5 mm from the metal tip. In the drift region outside

this volume, charged species diffuse towards the planar electrode and are collected. [82]

Plasma jet

Figure 34 shows the scheme of the atmospheric pressure plasma jet. The new source consists of two concentric electrodes through which a mixture of helium, oxygen and other gases flows. Ignite the gas discharge by applying 13.56 MHz RF power to the inner electrode at a voltage between 100-250 V. [87]

The ionized gas from the plasma jet is expelled through a nozzle where it is directed a few millimeters downstream to the substrate⁽⁷⁰⁾. [82, 87] Under typical operating conditions, the gas velocity is around 12 m/s and the exhaust gas temperature was previously close to 150°C. This source has been used to etch polyamide, tungsten, tantalum and silicon dioxide.⁽⁷¹⁻⁸⁰⁾

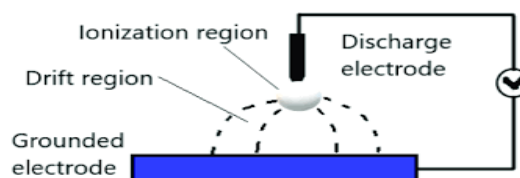


Figure 33: schematic diagram of a point-to-surface corona

Dielectric barrier discharge

Dielectric barrier discharge (DBD) is a kind of cold gas discharge between two electrodes wherein at least one of the two electrodes is covered with a dielectric barrier layer such as glass, quartz or ceramics. An alternating voltage or a repetitively pulsed power source can be used to power the DBD reactor. The function of the dielectric layer between the electrodes is to prevent the formation of arc discharge and to limit the DBD current. A space gap ranging from 0.1 mm to few cm is commonly applied under atmospheric air condition. DBD is filamentary in nature with discharge channels or streamers forming at random locations along the dielectric due to the charge accumulation on the dielectric surface. The filaments carry the energy and the active species of the discharge.

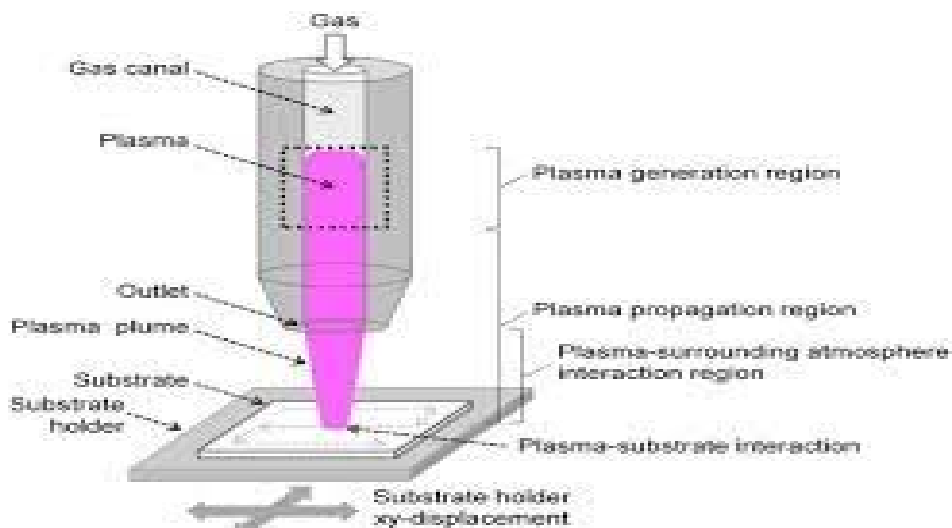


Figure 34: scheme of the atmospheric pressure plasma jet

DBDs at atmospheric pressure are classified into the inhomogeneous filamentary discharge and homogeneous or diffuse modes. The type of discharge is dependent on the operating parameters such as amplitude, frequency and waveform of the voltage applied, the capacitance and surface properties of the dielectric material and of the uncovered electrode, the gap distance between the electrodes and the composition of the gas in the gap. The homogenous mode and filamentary mode of DBD can be easily distinguished, where filamentary discharge is generated in a numerous filament Figure, and homogenous discharge is a uniform discharge covering the electrode.

The filamentary discharge is the most often used plasma Figure for industrial surface treatment of polymer foils at atmospheric pressure. It is the most common DBD operational mode. The ignition of this discharge does not need special requirements and is thus easily established. In filamentary DBDs the electrical breakdown starts almost simultaneously at many points of the surface and proceeds with the development of a large number of short-lived micro discharges of about 100 μm radius, each one generated from a streamer breakdown. Due to the short duration of the micro discharges and their small volume in comparison with the entire gas gap, plasma remains strongly non-thermal. The filaments are spatially and temporally separated from each other. Figure 35 shows filamentary discharge mode in nitrogen at atmospheric pressure. [87, 89-92]

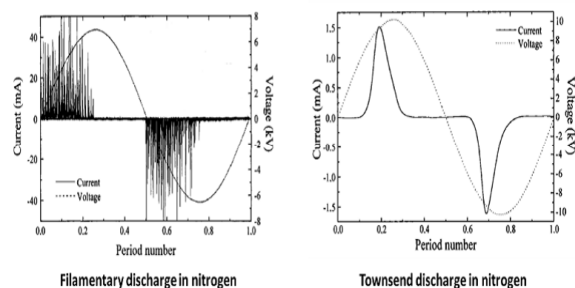


Figure 35: Discharge current of (a) the filamentary and (b) the glow discharge in nitrogen

Glow discharge mode

Uniform discharges in different gases such as helium and argon were created. Atmospheric pressure glow discharges could show that highly specific conditions, such as electrode structure, frequency and amplitude of the power supply, gap distances and type of dielectric material, will lead to glow discharges in certain gases. The homogeneous discharge mechanism of helium, neon and argon is similar to the DC glow discharges at low pressure and has the same voltage and current characteristics. Figure 36 shows glow discharge mode in argon at atmospheric pressure.

The main difference of the two modes is the concentration of the seed electron that is able to initially sustain the discharge. If the concentration of the seed electrons is low, the discharge is sustained in filamentary mode. Each seed electron accelerates to the instantaneous anode, making an avalanche which is developed to form the stream. On the other hand, if the concentration of the seed electrons is high enough to make small avalanches, these avalanches interfere to prevent any localization of the discharge and in turn prevent the stream formation. The condition to avoid stream formation is the ability to produce

electrons in small electric field in order to avoid a fast growth of electron avalanche the effect of changing the type and the arrangement of the dielectric barrier on the characteristics of the discharge was studied. Using different types of dielectric acquires the discharge different properties. [93]

The filamentary and the glow modes can often be readily distinguished with the human eye, because the homogeneous discharge Figures are uniformly distributed over the electrode area, whereas the filamentary discharge consists of spatially divided filaments. In the filamentary mode there are a multitude of current transients of nanosecond durations. In contrast, the glow discharges show a single peak of microsecond duration with each voltage half cycle. illustrates the discharge current and the applied sinusoidal voltage of the filamentary and the Townsend discharge in nitrogen. [94]

Another method for ignition of glow discharge plasma at atmospheric pressure involves the use of the nanosecond repetitive pulsed technology. The repetition frequency reaches the kHz range. As a result of the short pulse duration, the discharge stays uniform, because the electron avalanches do not have the necessary time to attain the critical level of ionizations, which avoids the transition to the filamentary discharge. This technology offers the possibility to ignite stable glow discharges in gases such as air and nitrogen. However, this technology is currently too expensive for industrial applications. [95, 96]

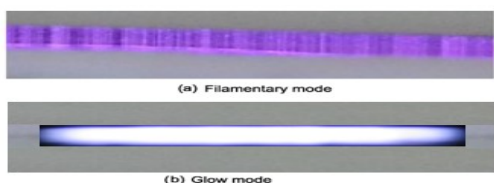


Figure 36 : DBDs modes in argon at atmospheric pressure (a) Filamentary, (b) glow mode

Basic types and Common configurations of DBD

In particular, DBD operated at the atmospheric air condition and 50 Hz power source is attractive because of its simplicity in configuration and power system. The DBD reactor can also be scaled up in size or volume for industrial application. The flexibility of DBD configuration is also one of the advantages to be considered. The different geometric arrangements can be classified into volume and surface discharge configurations. [97]

Surface discharge configuration

Surface DBDs have in contrast to the volume DBDs no gas gap, because it is replaced by a dielectric. Therefore the discharge occurs in the space between the two electrodes on the surface of the dielectric. Figure 37 shows the collection of different

DBD arrangements for surface discharge configuration. The arrangements shown are ordinary surface discharge (A), coplanar discharge (B), single electrode actuator (C) and (D) multielectrode actuator. [98-102]

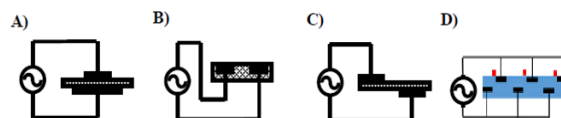


Figure 37: The collection different DBD arrangements for surface discharge configuration.

Plasma-Substrate Interactions

In the plasma, reactive species (positive and negative ions, atoms, neutrals, metastable and free radicals) are generated by ionization, fragmentation and excitation. These species cause physical and chemical interactions between the plasma and the substrate surface, which depend on plasma conditions such as gas, power, pressure, frequency, and exposure time. However, the depth of interaction and modification is independent of gas type and limited to 5 mm. Figure 38 illustrates the possible mechanism of the plasma-substrate interaction. [103-105]

Contamination Removal

Contamination may exist in the Figure of residues, mold release agents, anti-oxidants, carbon residues or other organic compounds, which prevents adequate adhesion. Oxygen plasma is commonly used excellent process for removing organics. Oxygen plasma causes a chemical reaction with surface contaminants resulting in their volatilization and removal from the plasma chamber. Sufficient care must be taken while choosing cleaning process parameters to ensure that only organics are completely removed. It is possible that the surface may modify instead of removing contamination. [106]

Etching

Roughening of the surface can play a significant role in adhesion by increasing the total contact area between the adhesive and the subsurface. Plasma etching can be used to remove material from a surface. Etching can be accomplished with either active or inert gases and can cause extremely porous surfaces by long exposure to the plasma Figure 39. [107]

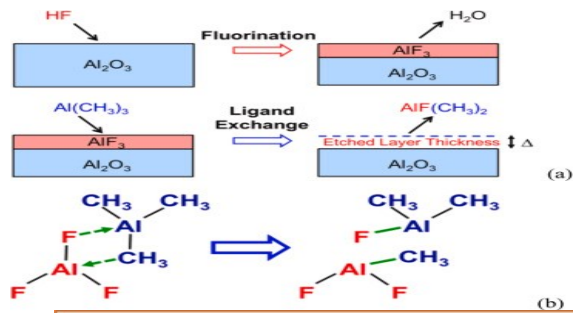


Figure 39 Etching mechanism

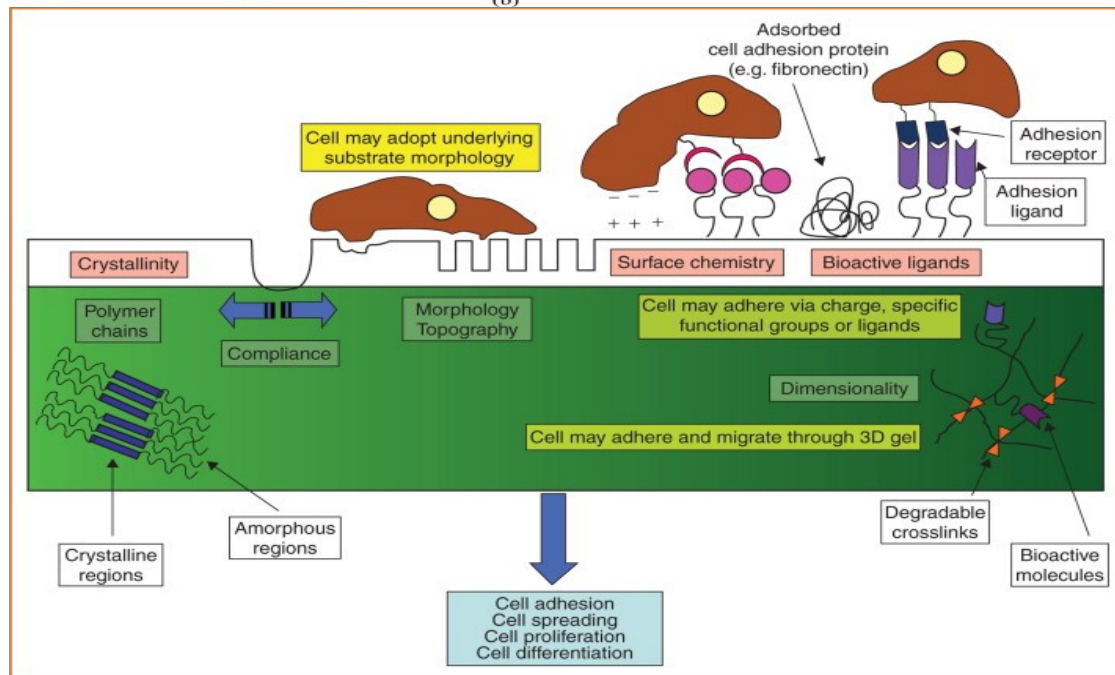


Figure 38: the possible mechanism of the plasma-substrate interaction

Cross Linking

Cross-linking employs inert gases such as argon or helium to remove some atomic species from the surface, and generates reactive surface radicals (Figure 40). These free radicals in turn recombine on the surface causing a stable cross-linking of the surface structure. Argon plasma effectively sputters nanometers of material from the sample surface, by roughening the surface on the nanometer scale. The cross-linking improves the adhesion of metal layers to the plasma treated polymer laminate. [73]

Plasma modification

Plasma modification represents an innovative eco-friendly approach to classical chemical modification. Cold plasma has recently emerged as an innovative technology for functional modification of surfaces and food components. Plasma is a mixture of excited gas molecules, atoms, ions, and free radicals, coexisting with quantum radiation, which (Figures 41

and 42) provides a basis for the effectiveness of cold plasma on material processing. Non-thermal plasma processing is an emerging green technology with great potential to improve the surface properties of materials. Production Plasma treatment can replace existing wet process steps. Examples are the treatment of wetting and adhesion properties, such as to facilitate dyeing, coating and manufacturing composites, while saving environmental costs. [74]

The associated cost savings are:

- Reduction in the amount of chemicals required for wet processing after plasma treatment; consumption of chemicals in bathtubs; reduction in BOD/COD of discharged process water.
- Reduce wet treatment time; this can make up for the extra time that treatment may require.
- Lower required wet processing temperature; saves thermal energy. [82]

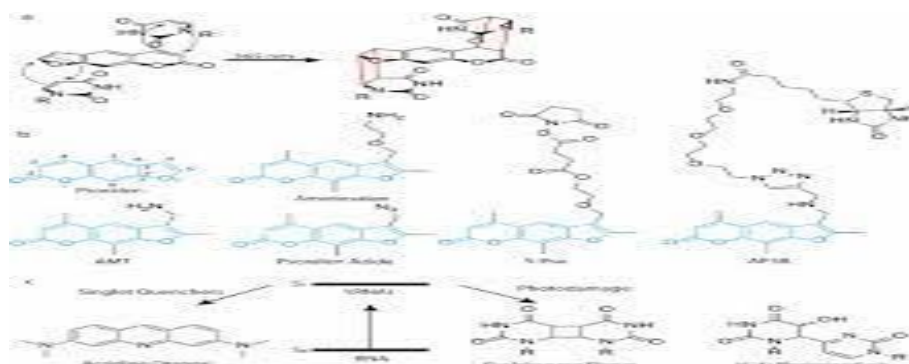


Figure 40: Cross Linking mechanism

Conflict of Interest

There is no conflict of interest in the publication of this article.

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تقنية البلازما لتحسين خواص المثخن الطبيعي في طباعة المنسوجات

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تم استخدام التعديل الكيميائي في عملية استخراج المثخنات الطبيعيه من البذور في وقت مبكر كأداة لإضفاء خصائص جديدة عليها وزيادة استخدامها الفعال لمختلف المجالات الطبيه والاطعمه واستخدامها ايضا في التطبيقات الصناعيه كطباعة المنسوجات. و في الوقت الحاضر ، يمكن أن تحل التقنيات الفيزيائية محل بعض هذه التعديلات الكيميائية كعمليات امنه و صديقة للبيئة. تعتبر المعالجة بالبلازما واحدة من هذه التقنيات الفيزيائية المطبقة على معالجه المثخنات وتحسين خواصها الريولوجيه واستخدامها في عمليات طباعه النسيج. إنه مجال سريع النمو وفي وقتنا الحالي يفضل استخدام هذه التقنيات الفيزيائية لتحل محل المعالجات الكيميائيه فى التطبيقات الطبيه والصناعيه كعملية صديقة للبيئة. لا تتضمن المعالجة بالبلازما استخدام مواد كيميائيه خطرته مضره للبيئه ، وبالتالي لا توجد مشاكل في النفايات السائلة مقارنة بالمعالجة الكيميائية.